GEOMORPHIC RESPONSES TO RAPID DENUDATION RATES IN THE NW HIMALAYA AND KARAKORAM§

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Analysis of high-resolution digital topography for the Kohistan-Karakoram Himalaya area near Nanga Parbat provides new information on the geomorphic response to some of the fastest cooling and denudation rates on the earth. Apatite cooling ages (Zeitler, 1985) and cosmogonic strath terrace ages (Leland et al., 1994; Burbank et al., 1994) both indicate rapid rates of erosion in this area. Measured incision rates range from ~2 mm/yr east of the Nanga Parbaf-Haramosh Massif (NPHM) to 6–9 mm/yr where the NPHM is cut by the Indus River gorge. The present topography presumably represents a balance between the tectonic and erosion processes, and the latter have been affected by Quaternary climate changes. Geometric arguments suggest that incision rates are approximately equal to bedrock uplift rates and that these rates have been sustained for' ≥0.5 my.

Several quantitative geomorphic measurements have been derived from the digital elevation model (DEM—three arc-second or ~90 m grid), including hillslope angles, local relief, valley widths, and hypsometry. The hillslope angles and local relief were calculated with analysis windows of varying sizes from (~250 m to ~4 km across) to characterize their dependence on scale. The slope of a given window size is defined as the slope of the best-fitting plane to all of the points of that window, while the relief is defined as the difference between the maximum and minimum elevations within the window. Statistics such as slope histograms and hypsometry (elevation histograms) were determined for the studied regions.

Hillslope angles measured with -250 m windows (the highest resolution reliably determined from this DEM) appear to reflect the dominance of landsliding in hillslope erosion, but not the variations in rock uplift rates in this area. There are no significant differences in slope histograms between the areas of very rapid (6-9 mm/yr) and rapid (~2 mm/yr) denudation. There is a small difference between the slopes in the non-glaciated valleys where slope histograms are narrowly peaked between 30–45° and the generally higher elevation glaciated areas where the slopes have a bimodal histogram with shallow slopes in the valley bottoms and steep slopes along the valley walls. Even in the glaciated zones, there are still only small areas with slopes greater than about 45°. This suggests that the rock-strength limitation on slope is perhaps 45–50° in this region where all of the units are medium- to high-grade crystalline rocks. The relatively narrow range of slopes may reflect a state of self-organized criticality where the rocks are everywhere close to slope failure as in sandbox experiments.

There are also some other areas with shallow slopes that appear to be remnants of low-relief surfaces now at elevations of 4000–5000 m. The most outstanding example is the Deosai plateau, but there are other surfaces with more subtle appearances. These surfaces are expressed as shallow-slope, low-relief areas with large peaks in their hypsometry at an elevation between 4000 m and 5000 m. To the west of the Indus River and NPHM and south of the Hunza and Gilgit Rivers is a low-relief surface at an elevation of about 4300 m, called the Gamugah or Kohistan surface, This surface is

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remarkably level in its more than 50 km east-west extension. If it is a remnant of a previous regional plateau, it would indicate little or no warping of that surface has occurred since it was formed.

References

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